

REMARKS**Amendments to the Claims**

Claims 1 and 9 have been amended to recite specific examples of mixed metal oxides. Support for the specific examples can be found in original Claim 8, and in the specification at, for example, page 5, lines 18-25, and page 8, lines 27 through page 11, line 15.

Claims 2-4 and 12-16 have been amended to be consistent in claim language.

Claims 5-7 are canceled.

Claim 8 has been amended to recite further specific examples of the mixed metal oxides recited in Claim 1. Support for "iron (Fe) and manganese oxide selected from the group consisting of MnO and MnO₂" can be found in the specification at, for example, page 9, lines 2-5. Support for "vanadium oxides selected from the group consisting of VO, VO₂, V₂O₃ and V₂O₅" can be found in the specification at, for example, page 10, line 26 through page 11, line 4. Support for "FeO and Fe₂O₃" can be found in the specification at, for example, page 11, lines 12-15, where it teaches iron oxides (Fe_xO_y) can remove a number of contaminants, and page 8, lines 29-32, where it teaches FeO and Fe₂O₃ as examples of iron oxides.

Claim 9 has further been amended to recite the step of "exposing the adsorbent to an oxidizing agent to oxidize the adsorbent" of original Claim 9. Also, Claim 9 has further been amended to claim Applicants' claimed invention more clearly by reciting the step of heating "the adsorbent that has been used for the purification of carbon dioxide." Support for this amendment can be found in the specification at, for example, page 4, lines 9-11, page 6, lines 21 through page 7, line 7.

Claim 17 has been rewritten in independent form, reciting all of the claim elements of original Claim 1. Claim 17 has further been amended to recite the step of "exposing the adsorbent to an oxidizing agent to oxidize the adsorbent" of original Claim 9 referenced to in original Claim 17. Claim 17 has further been amended to claim the claimed invention more clearly.

New Claims 18-23 have been added. Support for the recited specific examples of mixed metal oxides are as described above for the amendments of Claims 1 and 9.

New Claim 24 recites all of the claim elements of original Claim 15 and its base original Claims 9 and 14.

Amendments to the Specification

A self-evident typographical error at page 2, line 21 of the present specification has been corrected. In view of this amendment, Applicants respectfully request withdrawal of the objection to the specification.

Allowable Subject Matter

The Examiner stated that Claims 15 and 17 would be allowable if rewritten in independent form, including all of the claim elements of the base claims and any intervening claims.

As discussed above, Claim 17 has been rewritten in independent form, including all of the claim elements of its base Claims 1 and 9, as filed. Independent, new Claim 24 recites all of the claim elements of original Claim 15, including all of the claim elements of base Claims 9 and 14, as filed. New Claims 21-23 depend from Claim 17. As such, Claims 17 and 21-24 are allowable.

Claim Rejection under 35 U.S.C. § 112, Second Paragraph

Claims 9-16 are rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which Applicants regard as the invention. In particular, the Examiner stated that although Claim 9 is identified as being original, the oxidizing step of original Claim 9 is missing in the claim.

In view of the claim amendments discussed above, Applicants believe that Claims 9-16, as amended, are clear and concise, particularly pointing out and distinctly claiming the subject matter which Applicants regard as the invention. Accordingly, Applicants respectfully request that the Examiner reconsider and withdraw this rejection.

Claim Rejections Under 35 U.S.C. § 102

A. Summary of the Rejections

Claims 1 and 5-8 are rejected under 35 U.S.C. § 102(b) as being anticipated by EP 0 698 577 (hereinafter "EP '577"). Claims 1 and 5-8 are rejected under 35 U.S.C. § 102(b) as being anticipated by EP 0 952 111 (hereinafter "EP '111"). Claims 1-7 are rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. 6,537,514 to Prasad, *et al.* (hereinafter "Prasad '514"). Claims 1-8 are rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. 2002/0041842 to Ruettinger, *et al.* (hereinafter "Ruettinger '842"). Claims 1 and 5-8 are rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. 5,244,641 to Khare (hereinafter "Khare '641"). Claims 9, 10, 12-14 and 16 are rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. 5,186,727 to Chang (hereinafter "Chang '727").

B. Applicants' Claimed Invention Is Novel Over the Cited References

1. Applicants' Claimed Invention

As discussed above, as amended, the methods of independent Claims 1 and 9 employ at least one mixed metal oxide that includes: iron (Fe) and manganese oxide (MnO_x); nickel oxide (NiO) and titanium oxide (TiO_x); palladium oxide (PdO_x) and cerium oxide (CeO_x); vanadium oxides (VO_x); nickel (Ni) and nickel oxide (NiO); or iron oxides (Fe_xO_y).

2. With respect to EP '577

EP '577 discloses a process for removing sulfur compounds from a gaseous CO_2 feed stream by the use of COS hydrolysis with water and alumina (Section B of FIG. 1 of EP '577), and the subsequent use of H_2S removal with iron oxide, nickel oxide or manganese oxide (Section C of FIG. 1 of EP '577). EP '577 also discusses the use of an optional gas polishing step (Section D of FIG. 1 of EP '577) after the H_2S removal step, employing copper oxide, zinc oxide, or a mixture thereof.

EP '577, however, does not disclose or suggest the use of the recited mixed metal oxides of independent Claim 1 of the present application. In particular, none of the steps of EP '577 employ the specific mixed metal oxides recited in independent Claim 1.

Also, EP '577 does not teach a method of activating and regenerating the disclosed purifying materials after its purifying steps. In particular, EP '577 does not teach activation and regeneration of a mixed metal oxide adsorbent that includes Applicants' specific mixed metal oxide, as recited in Claim 9. Further, EP '577 does not teach activation and regeneration of the mixed metal oxide adsorbent, employing both the exposure of the adsorbent to an oxidizing agent to oxidize the adsorbent, and the subsequent exposure of the oxidized adsorbent to a reducing agent. As such, independent Claims 1 and 9 are novel over EP '577.

3. With respect to EP '111

EP '111 discloses a CO₂ purification system, employing catalytic oxidation system **14** using a metal catalyst, such as platinum (Pt), palladium (Pd), vanadium (V) and nickel (Ni) in combination with oxygen (O₂). EP '111 also discloses sequential treatment of a CO₂ stream with mixed metal oxide adsorber bed **60** having zinc or copper oxides, and catalytic oxidation system **61**, as shown in FIG. 5.

EP '111, however, does not disclose or suggest the use of the recited mixed metal oxides of independent Claim 1 of the present application. In particular, the metal catalysts employed for catalytic oxidation system **14** do not include any metal oxides. Also, although EP '111 discusses sequential treatments of a CO₂ stream with mixed metal oxide adsorber bed **60** and catalytic oxidation system **61**, the mixed metal oxide adsorber bed and catalytic oxidation system of EP '111 do not include, separately or in combination, any mixed metal oxide recited in independent Claim 1.

Also, EP '111 does not teach a method of activating and regenerating the disclosed purifying materials after its purifying steps. In particular, EP '111 does not teach activation and regeneration of a mixed metal oxide adsorbent that includes Applicants' specific mixed metal oxide, as recited in Claim 9. Further, EP '111 does not teach activation and regeneration of the mixed metal oxide adsorbent, employing both the exposure of the adsorbent to an oxidizing

agent to oxidize the adsorbent, and the subsequent exposure of the oxidized adsorbent to a reducing agent. As such, independent Claims 1 and 9 are novel over EP '111.

4. With respect to Prasad '514

Prasad '514 discloses a method for producing CO₂ from feed 12 of O₂-containing process gas (e.g., air) and feed 14 of carbon-containing process gas (e.g., methane). In the method of Prasad '514, O₂ selective ion transport membranes are employed to transport O₂ gas from cathode side to an anode side where the O₂ gas reacts with carbon-containing process gas to produce CO₂. The oxygen selective ion transport membranes include perovskites and dual phase metal-metal oxide combinations of Table 1.

There is no disclosure or suggestion in Prasad '514 of Applicants' claimed invention. It is respectfully noted that the method of Prasad '514 is for *producing* CO₂, *as opposed to purifying* CO₂. Also, the metal-metal oxide combinations of Table 1 of Prasad '514, which was referenced to by the Examiner, are for oxygen selective ion transport membranes, which selectively *permeate* O₂ gas, *as opposed to removing* O₂ gas. Further, Prasad '514 does not teach the use of Applicants' specific mixed metal oxides for purifying CO₂. Also, Prasad '514 does not teach activation and regeneration of a mixed metal oxide adsorbent that includes Applicants' specific mixed metal oxide, as recited in Claim 9. In addition, Prasad '514 does not teach activation and regeneration of the mixed metal oxide adsorbent, employing both the exposure of the adsorbent to an oxidizing agent to oxidize the adsorbent, and the subsequent exposure of the oxidized adsorbent to a reducing agent. As such, independent Claims 1 and 9 are novel over Prasad '514.

5. With respect to Ruettinger '842

Ruettinger '842 discloses a method for removing H₂S from a hydrogen gas stream using a monolith substrate on which is disposed zinc oxide, and a second metal, such as copper, nickel, iron or manganese, or oxide thereof.

There is no disclosure or suggestion in Ruettinger '842 of Applicants' claimed invention. In particular, Ruettinger '842 does not teach the use of Applicants' specific mixed metal oxides recited in independent Claim 1. Moreover, Ruettinger '842 does not teach purification of a stream of CO₂. Ruettinger '842 only discusses a hydrogen gas stream which does not have

substantial amounts of CO₂ for its method of removing H₂S (see, for example, [0012] and Example 2 at [0062]). As discussed on page 4, lines 27-30 of the present specification, purification of CO₂ is exceptionally difficult partly because CO₂ can react with adsorbent materials, such as metal oxides and render them inactive.

Also, Ruettinger '842 does not teach activation and regeneration of a mixed metal oxide adsorbent that includes Applicants' specific mixed metal oxide, as recited in Claim 9. In addition, Ruettinger '842 does not teach an activation and regeneration of the mixed metal oxide adsorbent, employing both the exposure of the adsorbent to an oxidizing agent to oxidize the adsorbent, and the subsequent exposure of the oxidized adsorbent to a reducing agent. As such, independent Claims 1 and 9 are novel over Ruettinger '842.

6. With respect to Khare '614

Khare '614 discloses a method of removing hydrogen sulfide from a gas. The method of Khare '614 employs an adsorbent composition consisting essentially of i) *chemically* combined nickel, zinc, iron and oxygen, i.e., nickel-zinc ferrite of Ni_xZn_yFe₂O₄ (see column 2, lines 33-41, Claim 1 and Example 1) and ii) alumina and/or silica. As described in Example 1, the nickel-zinc ferrite of Khare '614 is synthesized from an admixture of Fe₂O₃, ZnO and NiO. It is respectfully noted that the nickel-zinc ferrite is an entirely different compound from Fe₂O₃, ZnO or NiO, or an admixture thereof.

There is no disclosure or suggestion in Khare '614 of the use of Applicants' specific mixed metal oxides recited in independent Claim 1 for purifying CO₂. Also, Khare '614 does not teach activation and regeneration of a mixed metal oxide adsorbent that includes Applicants' specific mixed metal oxide, as recited in Claim 9. In addition, Khare '614 does not teach an activation and regeneration of the mixed metal oxide adsorbent, employing both the exposure of the adsorbent to an oxidizing agent to oxidize the adsorbent, and the subsequent exposure of the oxidized adsorbent to a reducing agent. As such, independent Claims 1 and 9 are novel over Khare '614.

7. With respect to Chang '727

Chang '727 discloses a mixed metal oxide absorbent having superior *carbon dioxide* and water *removal* capacity. The mixed metal oxide absorbent of Chang '727 includes a salt of silver metal and a salt of a second metal chosen from the group consisting of magnesium, iron, cobalt, nickel and zinc. Chang '727 also discloses a method of regeneration of such mixed metal oxide absorbents, which employs heating the mixed metal oxide absorbent under pressure to remove carbon dioxide from the absorbent, and subsequently cooling the heated absorbent.

There is no disclosure or suggestion in Chang '727 of Applicants' claimed invention. In particular, Chang '727 does not teach purifying CO₂. It is noted that the mixed metal oxide absorbent of Chang '727 is for *removing* CO₂ from air, *i.e.*, the absorbent absorbs CO₂, thereby removing CO₂, as opposed to purifying CO₂ by removing contaminants included in a CO₂ stream. Moreover, Chang '727 does not teach the use of Applicants' specific mixed metal oxides recited in independent Claim 1 for purifying CO₂. Also, Chang '727 does not teach activation and regeneration of a mixed metal oxide adsorbent that includes Applicants' specific mixed metal oxide, as recited in Claim 9. Further, Chang '727 does not teach an activation and regeneration of the mixed metal oxide adsorbent, employing both the exposure of the adsorbent to an oxidizing agent to oxidize the adsorbent, and the subsequent exposure of the oxidized adsorbent to a reducing agent. It is noted that the activation or regeneration method described at column 3, lines 24-42 of Chang '727, which is referenced to by the Examiner, does *not* employ exposure of the absorbent of Chang '727 to an oxidizing agent and the exposure of the same adsorbent to a reducing agent; the method employs only the heating step of the absorbent under pressure to remove carbon dioxide from the absorbent, and the subsequent cooling step. As such, independent Claims 1 and 9 are novel over Chang '727.

C. Summation

As discussed above, the subject matter of independent Claims 1 and 9 is novel over the cited references, namely, EP '577, EP '111, Prasad '514, Ruettinger '842, Khare '614 and Chang '727. Claims 2-4 and 8 depend from Claim 1, and Claims 10, 12-14 and 16 depend from Claim 9. As such, the subject matter of these dependent claims is also novel over the cited references at

least for the reasons discussed above. Accordingly, Applicants respectfully request that the Examiner reconsider and withdraw these rejections.

Claim Rejections Under 35 U.S.C. § 103(a)

Claim 11 is rejected under 35 U.S.C. 103(a) as being unpatentable over Chang '727.

Claim 11 depends from independent Claim 9. As discussed above, Applicants' claimed invention of Claim 9 employs a mixed metal oxide adsorbent that includes at least one Applicants' specific mixed metal oxide, *i.e.*, a mixed metal oxide that includes: iron (Fe) and manganese oxide (MnO_x); nickel oxide (NiO) and titanium oxide (TiO_x); palladium oxide (PdO_x) and cerium oxide (CeO_x); vanadium oxides (VO_x); nickel (Ni) and nickel oxide (NiO); or iron oxides (Fe_xO_y). As discussed at page 3, lines 26-31, Applicants' mixed metal oxide material includes a component in relatively high oxidation state for removing oxidizable contaminants (*e.g.*, COS), and a component in relatively in low oxidation state for removing reducible contaminants (*e.g.*, H_2). Thus, Applicants' mixed metal oxide adsorbent allows for removal of a broad range of contaminants from a CO_2 stream.

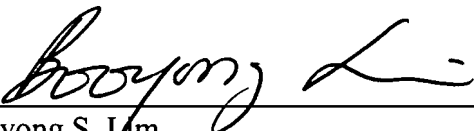
As discussed above, Chang '727 does not teach activation and regeneration of a mixed metal oxide adsorbent that includes Applicants' specific mixed metal oxide, as recited in Claim 9. Further, the mixed metal oxide adsorbent of Chang '727 is for removing CO_2 from air. As such, there is no teaching in Chang '727 of any purifying material that has a component in relatively high oxidation state for removing oxidizable contaminants (*e.g.*, COS), and that has a component in relatively in low oxidation state for removing reducible contaminants (*e.g.*, H_2). Accordingly, there is *no* teaching in Chang '727 of a regeneration method that employs both the exposure of a metal oxide adsorbent that has been used for purifying CO_2 to an oxidizing agent, and the subsequent exposure of the oxidized adsorbent to a reducing agent, to thereby form an activated metal oxide having a component in relatively high oxidation state and a component in relatively low oxidation state. As such, Applicants' claimed invention of independent Claim 9 and claims dependent therefrom is non-obvious in view of Chang '727. Accordingly, Applicants respectfully request that the Examiner reconsider and withdraw this rejection.

CONCLUSION

In view of the above amendments and remarks, it is believed that all pending claims are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned.

Respectfully submitted,

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